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ILLINOIS STATE LABORATORY

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THE INSECT, THE FARMER, THE TEACHER, THE CITIZEN,
AND THE STATE

BY
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THE INSECT, THE FARMER, THE TEACHER, THE CITIZEN, AND THE STATE*

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When, a year and a half ago, entomology was separated from zoology as a department at the University of Illinois, I was asked by one of the college deans if I did not think that it was too limited and subordinate a subject for departmental independence. I replied that entomology was really the larger half of zoology—an answer which was taken as jocular and received with some amusement, but which was intended seriously, and which can be substantially justified from several points of view.

In the first place, it has been estimated by a conservative naturalist of world-wide reputation that more than half of the animal matter of the land surfaces of the globe is locked up in the bodies of insects. That is to say, if all the elephants and lions and buffaloes and horses and cattle and hogs and birds and snakes and lizards of the earth were put into one pan of a gigantic balance, and all its insects into the other, the insect collection would be found to outweigh all these other land animals taken together. It is difficult, of course, to prove that this is so, but the very fact that a naturalist of established reputation should deliberately put forth such a statement in an important work shows how dominant a position insects occupy in the life of the world. Undoubtedly the number of species of insects in the world greatly surpasses that of all other terrestrial animals; which is another way of saying that the number of fixed variations of structure, form, color, and the like, to be found in insects is greater than that presented by all other land animals. By reason of this extraordinary power of variation, and hence of adaptation—of fitness to various conditions and situations—insects are very widely distributed, and are found in a greater variety of places and surroundings than any other class of land animals on the earth. They are able to maintain themselves, in other words, in a greater number of ways and

* An address delivered December 13, 1910, to a joint meeting of teachers and farmers at Normal, Ill.

to avail themselves of a larger variety of the resources of the earth than any other animals. They are, in fact, of all land animals, the most successful class, the best adapted to the conditions of life on earth of any that now exists, or ever has existed.

Among their most extraordinary attainments is a tribal organization which actually surpasses anything known among primitive men. Their industrial classes are not such by choice or by accident merely, but by instinct, and by original and exclusive inclination and capacity. Their soldiers fight, their workers work, their housekeepers keep house, and their fathers and mothers fulfil their appropriate functions just as "dogs delight to bark and bite," because "it is their nature to"; and such is the prevailing spirit of self-sacrifice for the general good of a group of the so-called social insects that it is scarcely too much to say that any bee or wasp or ant might well become a candidate for a Carnegie medal almost any day of its life.

Possessed of all these powers and capacities, it is not to be wondered at that we find among them dangerous and tireless competitors with ourselves for the use and control of the earth. The struggle between man and insects began long before the dawn of civilization, has continued without cessation to the present time, and will continue, no doubt, as long as the human race endures. It is due to the fact that both men and certain insect species constantly want the same things at the same time. Its intensity is owing to the vital importance to both of the things they struggle for, and its long continuance is due to the fact that the contestants are so equally matched. We commonly think of ourselves as the lords and conquerors of nature, but insects had thoroughly mastered the world and taken full possession of it long before man began the attempt. They had, consequently, all the advantage of a possession of the field when the contest began, and they have disputed every step of our invasion of their original domain so persistently and so successfully that we can even yet scarcely flatter ourselves that we have gained any very important advantage over them. Here and there a truce has been declared, a treaty made, and even a partnership established, advantageous to both parties to the contract—as with the bees and silkworms, for example; but wherever their interests and ours are diametrically opposed, the war still goes on and neither side can claim a final victory. If they want our crops they still help themselves to them. If they wish the blood of our domestic

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animals, they pump it out of the veins of our cattle and our horses at their leisure and under our very eyes. If they choose to take up their abode with us we can not wholly keep them out of the houses we live in. We can not even protect our very persons from their annoying and pestiferous attacks, and since the world began we have never yet exterminated—we probably never shall exterminate—so much as a single insect species. They have, in fact, inflicted upon us for ages the most serious evils without our even knowing it. It is the cattle tick which keeps alive and spreads the Texas fever; it is the mosquito which inoculates our blood with yellow fever and malaria; it is the house-fly which carries to our food the germs of typhoid fever; it is the flea of the rat and of other rodents which just now threatens all America with that dread disease, the bubonic plague,—and now that we have begun to discover facts of this order, many other instances of this kind will no doubt presently be brought to light.

Not only is it true that we have not really won the fight with the world of insects, but we may go farther and say that by our agricultural methods, by the extension of our commerce, and by other means connected with the development of our civilization, we often actually aid them most effectively in their competition with ourselves. Our rapidly growing, world-wide commerce of fruits and grains, our importation of new plants from the remotest regions of the earth, often bring their special insect enemies with them, and our exports of our own best varieties, in turn, have the practical effect of establishing a general international exchange of injurious insects, such that we seem certain to become the eventual prey of every insect species living anywhere on earth that can do us any harm.

I bring these facts together here in this general way to remind you that the difficulties we labor under are neither temporary nor exceptional, and to show you, as well as I can, that our struggle with insects is a serious and important matter, calling for the fullest knowledge and the most thoroughgoing experiment, and calling also for that kind of patriotism which consists in spending time and labor and money for the general welfare. We might as well expect to repel an armed invasion of our country by leaving every householder, unaided, to drive the enemy from his own door as to expect to quell insect attack upon our

persons and property without concerted measures of defense and without self-sacrificing effort for the common good.

It is worth our while, I am sure, to pause for a moment over the question, What is there in or about an insect—small, weak, simple, short-lived, ignorant, mechanical, and conservative to the last degree, as it is—which can give it any standing whatever in competition with a relatively huge, powerful, complex, intelligent, progressive, and resourceful being like man? It is, indeed, in these very points of its weakness that it finds its greatest strength. Its small size makes it inconspicuous to our notice, and enables it to find shelter and support in multitudes where a single human being would perish from exposure or starve to death. Starting abreast of us, at its origin in a single minute germ cell, it can complete its simple process of development, grow to adult size, and begin to reproduce its kind in a few weeks or months, in some cases in a few days only, while we require perhaps twice as many years. It can thus fit itself much more rapidly and exactly to temporarily favorable conditions, and can retreat with much less loss from those unfavorable, than can a creature whose lumbering size, enormous demands, slow growth and still slower reproduction make it sluggish in response and clumsy in adaptation.

Furthermore, the feeding and respiratory capacity of a small animal is greater in proportion to its size and its individual necessities than is that of a large animal, and it has therefore a larger surplus of energy, derived from its food and oxygen, to dispose of. Its need of food and air for mere existence is proportionate to its bulk or mass, but its power of absorbing these is proportionate to its absorbent surfaces. As an animal grows, its bulk increases, and with this its need of nourishment, as the cube of its diameters; while its absorbent surfaces increase, and with these its powers of respiration and digestion, as the square of its diameters only. The square of a number being less than its cube, the larger of two animals will, other things being equal, have a smaller proportion of its energies to dispose of, beyond its bare needs for maintenance, than will the smaller one. Divide a hundredweight of living matter into ten thousand living animals and it will have a very much greater surplus of energy and activity to expend in impressing itself on the outer world than it could have if concentrated in a single animal weighing a hundred pounds. Grasshoppers, for example, can devour and absorb many times

as much food to the hundred pounds of flesh as can a man, and a hundredweight of these insects have consequently many times as much energy to expend, outside their bodies, as does a hundred-pound boy or girl. It is this which makes it possible for the beetle or the bug to multiply habitually at a rate which, if it were applied to man, would virtually destroy the race by over-population, perhaps within a single generation. It is this great surplus of available energy which enables an insect to exhibit activities and to perform mechanical feats altogether out of proportion to its size, if tried by the human standard. All these overflowing energies, I need not say, are available, and utilized by insects as a rule, in their own interest or in the interest of their family or tribe. Although contemptibly weak per unit of number, they are amazingly strong per unit of mass, and it is an enormous advantage to them, rather than a disadvantage, that the mass unit should be subdivided into a multitude of independent number units.

Insects are, indeed, at the climax of one of the great plans of animal structure and development, and man is somewhere near the culmination of another and a widely different plan. The competition of insects and men is thus largely a competition between two diverse systems of anatomy—that of the articulate, with its complicated external skeleton, on the one hand, and that of the vertebrate, with its internal skeleton on the other. Each has its advantages which the other can not possibly duplicate. It is like a war between two nations, one of which should so greatly excel in the construction of its firearms and the other in the quality of its ammunition that neither could ever gain a decisive and final victory.

Fortunately for us, however, our contest with insects is not between two kinds of structure merely—if it were we might not hope to win—but it is also between two types of mind. The insect mind is fixed and unchangeable; wonderfully adapted by nature to the normal demands upon it, but essentially the same for all of each species, virtually incapable of education and beyond the reach of improvement. The corn-field ant knows at its birth far better than a man what to do in a corn field in its own behalf; but the man can observe, and learn, and remember, and record, and imagine, and invent; can improve his methods, and cultivate his abilities, and can accumulate and transmit his learning and his records in an ever-increasing mass. The practical, exact, and effi-

cient, but wholly unimaginative and uninventive mind of the ant is at first a better instrument of adaptation and control than the vacant, unformed, but versatile and improvable mind of primitive man. It is only by slow degrees, with the accumulation of knowledge and the organization of methods in successive generations, that men and insects can come to have something like an equal chance in the struggle for supremacy; and it is only by further advances in these methods and along these lines—by investigation and education, in short—that we can hope finally to free ourselves from a humiliating subordination to what we not unreasonably call our “insect enemies.” Is the word “subordination” too emphatic? Suppose that our country had been invaded by a foreign enemy who had succeeded in completely overrunning it to such an extent that we were obliged to dispute with him, everywhere and all the time, the bare possession and use of our farms and homes, and the products of our toil; and suppose that we were not only totally unable to dislodge him from our premises, but that we were compelled to pay him a perpetual annual tribute, or tax in kind, of seven and a half dollars a head for each man, woman, and child in the land—a total of \$700,000,000 per annum for the whole United States—while we received from him in return, as a contribution to our maintenance, a bare \$6,000,000 worth a year of clover seed (which costs him nothing) and \$7,000,000 worth of honey and wax. Should we have any doubt as to which of the two competing populations was the subordinate one? While insects injure us to an amount approximately fifty times that of the benefits they confer, it is at best a doubtful question whether, taking all our activities into account, and their final effect on our whole insect population, we really do not benefit *them* in the long run more than we injure them; it is at least an open question whether they are not now more abundant in our territory, on an average and as a class, than they were when Columbus discovered America.

Insects are, in short, a finished evolutionary product, while man is still in the rough. There is no class of animals on this earth which gives an intelligent student a more vivid impression of perfect fitness to its maintenance, of perfect adaptation to its needs and its surroundings, of final and permanent finish, in short, than does this insect class. A bee or an ant is a polished gem in a perfect setting; or, better, we may say that the insect world is a perfectly built and precisely adjusted machine,

which has run continuously from time immemorial, without important modification and without repair, and which still whirls steadily on in its place, almost noiseless, almost frictionless, a marvel of precise and perfect work. The human world, on the other hand, is a great invention still in the making—not yet out of the inventor's shop—straining itself here as it turns, there grinding itself away, and every once in a while breaking down completely in this or the other part, with an appalling crush of timbers and crash of steel—as in some great war, or in some disastrous general strike.

Such are some of the considerations which led me to say to my literary colleague at the University—who laughed loudly into the telephone at the suggestion—that entomology signifies more to us than all the rest of zoology, and that it *really* is a subject large enough and important enough for a university department of instruction and research.

Let us now turn to a practical side of this discussion, and see what the great and wealthy state of Illinois is doing to help its citizens in this still unequal contest. I ought to say in the first place that, relatively to other states in the Union, Illinois is really doing very well. The president of the Entomological Society of America, Professor John B. Smith, of New Jersey, delivered last December an address to that society on the relations of insects and entomologists to the country at large, in the course of which he took occasion to say, in speaking of the early official entomologists of this state: "Illinois is another of the states which has never allowed its service to deteriorate, and there is no better work now done in the United States, nor is there any more effective organization than that within its limits." In speaking of this state, consequently, I am not selecting an unfavorable example, but quite the contrary.

Over forty years ago—in 1867, to be precise—in response to repeated and urgent appeals of its citizens, especially of its horticulturists, expressed in formal resolutions of a state society, Illinois enlisted a regular force for the war against insects, and provided what we may call a war fund for its use. This army consisted of one man, B. D. Walsh, of Rock Island, an entomologist of extraordinary ability and repute, and he was given—as a supply for his operations a two-thousand-dollar salary and nothing else. He performed as well as he could his various duties of private, captain, colonel, adjutant, and major-general of this new force—and in two years he was dead. He had two successors

enlisted for the war on precisely the same terms, the first of whom, Dr. Wm. Le Baron, of Geneva, Illinois, maintained for five years the unequal contest, when he also died; and the second, Dr. Cyrus Thomas, of Carbondale, abandoned the field in despair after seven years of diligent service, going then to Washington for work in another department of science, where he lived to the good old age of eighty-five. I have sometimes wondered if his long survival was not largely due to his fortunate escape from an untenable situation.

It was in 1882, twenty-nine years ago next July, that it fell to me to pick up the abandoned standard under conditions which made the contest seem a little less hopeless. Under the parsimonious policy of the state, which it seemed useless to try to improve, it may easily be believed that the entomologists had accumulated no public property, and not so much as a penny's worth of anything came into my hands as a product of their fifteen years' work. Being, however, already in the service of the state as director of a natural history survey, and blessed in that capacity with an office and one assistant, the beginning of a library, and a crude collection of insects, mainly bought of a village physician, it seemed possible, by an operation which in these commercial times might be called a merger, to make these meager facilities partly available to the Entomologist's office, and this was done. A little later, in 1884, the work was all established by law at the University of Illinois, and so associated with the department of instruction there that each division of the rather complex organization thus resulting derived some aid or advantage from the other; and under substantially these conditions we have continued until the present time.

The Entomologist's office, it should be said, is not now and never has been a department of the University of Illinois, but is both legally and financially independent of the university organization. Nevertheless, during this twenty-five year period of common management and joint operation it has become so interwoven in function and equipment with the related departments that the whole is virtually one indivisible enterprise of investigation, publication, and instruction. The Entomologist's office is, in fact, merely a differentiated part of the natural history survey of the state, dealing with insects, of course, and directed mainly to practical ends; and the corresponding university department of instruction is largely a training school of economic entomologists, from

which and from the state office so closely associated with it, a long line of young men has gone out, and is still going out year after year, for service in many other states and in the entomological bureau of the national Department of Agriculture.

Appropriations of twenty-three thousand dollars a year are now available to the office for all its work of investigation and inspection, and for the publication of its bulletins and biennial reports—a sum sufficient to enable it to maintain special assistants continuously in the field in different parts of the state, and to keep its work moving, although at much too slow a pace, on most of the lines of research for which it has been made responsible.

Organized war against injurious insects is thus at last provided for in Illinois, and what we may fairly call a corporal's guard of trained and experienced fighters is now constantly in the field. Their enemies can scarcely be said to have diminished in number, however, during the last twenty-five years, for the insect invasion of the state is still in progress. New armies cross our borders at frequent intervals, and fresh uprisings occur every now and then, of those already in our midst.

We are doing our best service, no doubt, in teaching the individual citizen how to defend his own property and person against marauding enemies, but this is a slow, tedious, and very difficult process. One of our greatest needs is that of recruits for the fighting squad, and these we are seeking to get in part by just such instruction work as is now in progress here. To drop the military figure, what we most need is aid in the work of popular instruction, without which the rest is virtually of no avail.

We have published from the Entomologist's office a total of 4,700 pages on the injurious insects of Illinois in twenty-five volumes of official reports. It is discouraging to think how little of the practical content of these papers is actually in the possession or at the personal command of the ultimate consumer—of the individual citizen—in whose interest this work has all been done and these reports have been prepared. It is to you, teachers and prospective teachers of the public schools, that we have mainly to look for aid in this dilemma. In helping forward the movement for agricultural education in the public school we should not forget that economic entomology is a part of scientific agriculture, that it has its share, in fact, in every division of that great complex subject—

how important a share I have attempted to show you as well as I could in general terms and in so short a time.

To the teacher of biology it is especially important to observe that while general entomology, like general botany and zoology as ordinarily taught in the schools, may be a science of observation and classification only, making almost no demand on the reasoning powers, economic entomology is an experimental science, and involves as a necessary feature the whole process of the scientific method. It may be made—it must be made, if it is to accomplish its main end—a means of training in observation, reflection, and invention, in experiment and verification, and so should have an educational value far greater than the biology of the ordinary high-school course. We are not weakening high-school science in making it really economic; we are making it actually more scientific than if its economic applications were ignored.

I intimated, a while ago, that although man is distinctively a social animal, he has something nevertheless to learn from insects with respect to the social spirit and to an organization for community service. It may seem marvelous, and indeed almost incredible, that this should be so. The fact, however, is beyond dispute; and the explanation of it is suggestive and important. We are less perfectly adapted than insects to the life we are called upon to live, because we have been living it for so short a time; we are less fitted for our environment than insects are to theirs, because we are progressive animals and change our own environment continuously, while they are stereotyped animals and stay in the same environment age after age; with them it is “once adapted, always adapted”; but with us old adaptations are often in the way—a hindrance instead of a help—for they fit us to an environment which has disappeared. We have voluntarily progressed, or have been pushed by the general improvement of progression, into situations to which our habits, our motives, and our traditions no longer correspond; we tend to do things which might have been the correct procedure a thousand or ten thousand years ago, but which are now so inadequate and unfit that we call them ignorant, or stupid, or wicked and wrong. For these mal-adjustments there is but one remedy with us; the cure for the evils of progress is more progress; as we change our environment we must also change ourselves.

Now the environment of the American farmer has changed, and is

still rapidly changing. A generation or two ago he was relatively solitary and independent; each might do about as he liked with his own and it was no one else's business; or, if this were not always so, no one was aware of the fact. Now, however, it certainly is so no longer; we suffer, all of us, in a thousand ways for other people's faults. The sins of the father are visited, not only at long range upon his children and his children's children, but at short range also upon his neighbor and his neighbor's family. As we are drawn, inevitably and irresistibly, year by year, into closer bonds of social and industrial companionship, we are bound to become socially and industrially more companionable; we must consent to restrictions, in each other's interest, which a generation ago would have been thought intolerable; we must volunteer habitually mutual services which were once uncalled for; we must approximate more closely the methods of the insect colony; we must learn to emulate "the spirit of the hive;" we must do intelligently, willingly, and purposely, as an act of mental and ethical adaptation to a novel situation, what insects learned ages ago to do unconsciously, structurally, physiologically, as a slow and costly result of physical and psychical variation fixed by natural selection.

All this is by way of an approach to the idea that the modern farmer not only owes it to himself, but owes it especially to his neighbors, not knowingly to breed injurious insects or other pests in his crops or on his premises to the subsequent injury of his community. An ant or a bee would never do the like; it would die first—would die, indeed, for very much less than that. It has learned long ago its lesson of individual service—of individual *sacrifice*, if necessary for the good of its community—learned it for the unanswerable reason that only thus can the individual welfare, involved as it is in the welfare of the community, be best promoted. We are only beginning to learn this lesson, but the sooner we get it learned the less will be the common loss, and the better will be our position to withstand the assaults of our better trained and better disciplined insect enemies. If the farmers of a community were as united, as unanimous, as public spirited, and as completely masters of the art and method of their calling, as are the ant communities which infest their corn fields, no one of them would ever lose his crop because of the corn root-aphis and the corn-field ant, because no one would allow these insects to multiply and mature to the destruction of his own

corn, and then to escape to the injury of that of his neighbors; all would avail themselves promptly and conscientiously of the facts and methods now known to us, sufficient for an arrest of injury and a destruction of the injurious agents; each would do this as a matter of principle—that is to say, as a matter of course—even if it seemed to diminish for a time the profit on his own operations and investments, because, secure in a like action by others, he would know that each would profit more by the public spirit of all than any one could profit by his own separate selfishness if all were to be equally selfish and short-sighted. This view of the farmer's duty to his community may seem somewhat utopian—as implying higher qualities in human nature than we have a right to expect at the present time; but why, indeed, should the farmer allow the chinch-bugs he has raised in his wheat to escape into his neighbor's corn any more than he should allow his cattle to break out of their pastures to feed on that neighbor's crops? Why should he breed mosquitoes in the waste overflow of the farm creek to infect his neighbor's family with the germs of malarial disease, when he may not let his child run free if suffering from diphtheria? Whatever the individual may say in reply to these pointed questions, the state is beginning to answer that there is no reason: and laws are being passed year after year to prevent just this kind of stupid and injurious selfishness.

We have had a law of just that description in this state for several years, and we owe its enactment to the San Jose scale—a Chinese insect which came secretly to this country by way of Japan in 1872. This was a case of Japanese invasion far more successful, and probably more destructive also, than any which Japan could possibly make by means of dreadnoughts and armies of little brown men. Establishing itself thoroughly on the Pacific Coast at San Jose, it next made a long leap quite across the continent to New Jersey, and from that state as a center it has dispatched its armies of invaders into every state in the Union, in some states into every county, and in some counties onto every farm. Armies of orchardists are now fighting it yearly everywhere, and train-loads of ammunition in the form of sulphur and lime, thousands of small arms in the form of spraying pumps, and hundreds of pieces of artillery—the great power sprayers—are in the hands of these armies; and in order that no indifferent noncombatant may give aid and com-

fort to the enemy which the rest are engaged in fighting, it is made by law a misdemeanor, punishable by a fine, to give it food and lodgment on one's premises. This same law, enforced by watchful inspectors, has been our sole, but sufficient, means of defense in this state against another destructive insect invader, the brown-tail moth, which would have been established by this time in scores of Illinois nurseries and hundreds of Illinois orchards if it had not been stopped and destroyed on its way from France before it had reached its destination. My own squad of inspectors captured and burned alive several hundred thousand of these French invaders in the winter and spring of 1908-09, and several thousands more in 1909-10. It is the object of such laws, not to compel the people to do their duty, but to aid them in defending their property by making their defense effective. These laws are also a great educational agency, for those charged with their administration and enforcement must, of course, show the people concerned just what to do and just how to do it to meet the obligations which the law imposes.

Of course there is not the slightest difference, in principle, between the special case of the San Jose scale and many other cases of dangerous insect injury to which the law has never yet been applied. If all the infested wheat stubble in the country were to be burned over or plowed under for a single summer, the additional precaution being taken to burn the chaff and screenings from infested fields at threshing-time, all the Hessian fly in the country would be at once destroyed, and subsequent injury by that insect would become impossible. It now causes the loss of many millions of dollars every year, and no one can fully protect himself against it because of the Hessian flies bred by his neighbors in their neglected fields. There is no more reason why these conditions should be permitted to continue than there is reason to permit the San Jose scale to range abroad at will; and when our people acknowledge this fact and are willing to support laws and regulations based upon it, we shall find legislatures and state officers ready enough to act according to their wishes. At present the farmer may appeal to the state law and the entomological inspector for the protection of his orchard or his raspberry patch against insects abroad in his neighborhood, but he must take care of his corn and oats and pastures for himself. In that undertaking the state gives him only information and advice, and no efficient aid.

Evidently we have, in this teeming world of insect life, one of the greatest forces of nature, largely hostile to our interests, and but slightly available for any of our purposes. Its conquest and control are one of the original remaining problems of our civilization to which we must give the same grade of skilled and thoughtful attention that we are giving to the mastery of contagious disease, itself largely an insect problem, or to the planning and making of a Panama canal.

The people of Illinois lately voted twenty millions of dollars for the construction of a ship canal, the value and need of which seem to be still matters of grave dispute—a sum which, at our present rate of expenditure, would run our state department of entomological investigation for eight hundred and seventy years. Our progress is too slow, and it is time to speed up.

And the new educational movement must help us on to give practical effect to what we already know, for it is our ignorance that hinders us. It is a reproach both to our education and to our industrial enterprise that we should have to make, in this beginning of the twentieth century, any such confession of incompetency as is contained in this paper. It is a hopeful sign of the day that the economic entomologist has, now and then, the opportunity to tell some part of his story of the ways of insects and their relation to human life and welfare to audiences like this, made up so largely of active and prospective teachers. It is a privilege I appreciate, and for which I heartily thank the managers of this institute.

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